RESEARCH HIGHLIGHTS

Socio-Economic Series Issue 49

IMPACT OF URBAN FORM AND TRAVEL ACCESSIBILITY ON PRIVATE VEHICLE USE

Introduction

As awareness grows of the environmental impacts of private vehicle use, many researchers and policy makers have been seeking ways to reduce car use. There is a growing body of opinion that reductions can be achieved through careful design of the urban built-form, including the encouragement of compact, mixed-use development patterns and improvements to transportation networks. But the degree to which such changes will result in reductions in automobile use is a source of debate. In order to make effective recommendations, it is important to have a thorough understanding of how land-use patterns affect car use. This study examines the factors influencing private automobile use by analyzing data on household travel behaviour collected in Edmonton.

In the following ways, this study fills significant gaps in our knowledge of the impact of urban form on vehicle use. These gaps were identified in a literature review conducted as part of this study:

- It uses empirical data on observed travel patterns in a Canadian city, resulting in conclusions that are more relevant for the Canadian context than previous empirical studies on this topic, which almost exclusively are based on data from other countries.
- It considers a wide range of measures that cover the complexity of influences on travel behaviour more completely than many previous studies. This includes mode-specific accessibility measures, which represent the spatial distribution of activities and account for parking costs, transit fares, traffic flow rates, and other factors.
- It employs multiple-variable regression to take into account the effects of collinearity among the explanatory variables. Many previous studies have overestimated the influence of certain factors, such as density, because they considered only one explanatory variable at a time, thus failing to account for the correlation with other variables.
- It considers a range of aspects of household travel behaviour, including mode choice, tour generation, and number of stops per tour for both compulsory and discretionary travel, along with auto ownership, thus providing a more complete view of the full range of influences on different aspects of travel.

Methodology

Multivariable regression analyses were conducted to determine the influence of a range of explanatory variables on various indicator variables related to household travel behaviour, including in particular the total vehicle kilometres travelled (VKT) by each household. Data on travel behaviour were derived from a household travel survey conducted in the City of Edmonton, in which over 6,000 households reported their travel activities for the full 24 hours of a randomly assigned fall weekday in 1994. In addition to daily household VKT, the influences on household car ownership as well as compulsory and discretionary trips and tours were examined.

The explanatory variables include various representations of urban form along with household demographic characteristics such as household income and size. Descriptions of urban form were developed by dividing the Edmonton CMA into 486 zones, each containing relatively homogenous urban form characteristics. The values for the variables (except demographic) assigned to each home and job location identified in the household survey correspond to the attributes of the zone in which they are located. Systems of nodes and links are used to represent the various networks of transport services, including the road network, the transit system, and walking and cycle paths.

The urban form variables fall into three categories:

- accessibilities measures are provided for each mode (i.e. automobiles, walking, cycling and transit) for zones containing the household and the containing employment locations. These variables account for the proximity of activities, such as shopping and housing (a combination of density and land use mix) and the ease of travel between these activities as provided by the

transport systems connecting them. A location's accessibility increases as the number of activities near it increases and as the utility of travel (ease, time, attractiveness and costs, including parking costs) to these activities increases.

- population and employment density; and
- neighbourhood road patterns.

Findings

Multi-variable regression equations with various combinations of explanatory variables were estimated using the observed data. Table 1 shows the estimation results for the statistically significant explanatory variables for daily household VKT from an estimation run that was judged to be the one that provided the most appropriate indications out of the set of runs considered.

The mode-specific accessibility variables are composite measures that reflect the combined effect of a number of different component factors. In order to obtain a more complete picture of the influences of each of these factors on private-vehicle use, sensitivity analysis was conducted. The component accessibility variables were individually reduced by 10 per cent and the resulting changes in total auto use were calculated. The results are summarized in Table 2.

Table 1:
Results of Significant Explanatory Variables for household VKT[1]

Explanatory variable description	t-ratio	elasticity at mean	relative impact of variable[2]
Number of private vehicles in household	18.0	0.434	***
Automobile accessibility for home zone	4.5	0.398	***
Annual household income category	5.2	0.152	**
Number of people in household	5.5	0.210	**
Number of full-time employees in household	7.0	0.149	**
Walk accessibility for home zone	-4.1	-0.091	**
Automobile accessibly for work zone	2.0	0.055	*
Transit "not available" in home zone	10.0	0.050	*
Number of part-time employees in household	3.2	0.019	*
Number of senior high-school students in household	4.9	0.019	*
Number of grade-school students in household	-1.5	-0.017	*
Strict rectangular grid road pattern in home zone	-1.9	-0.015	*
Primarily rectangular grid road pattern in home zone	-2.8	-0.016	*
Mix of rectangular grid with curvilinear pattern in home zone	4.0	0.012	*
Transit accessibility for home zone	-2.1	-0.016	*
Walk accessibility for work zone	-6.2	-0.017	*
Number of employees working at home in household	3.1	0.006	*

[1] Note that the estimated parameters for population density and employment density were not statistically significant when all of the above factors were included as explanatory variables.

[2] *** = strongest impact on auto VKT, ** = medium impact, * = minor impact

Table 2:
Changes in Daily Household VKT in Response to 10% Changes in Various Components of Accessibility Variables

Accessibility Component Change	Inner Area	Suburbs	Total City	Relative Impact of Variable[2]
Walk Time down 10%[1]	-3.79%	-3.02%	-3.25%	***
All Mode 'In' Times down 10%[1]	-2.80%	-2.25%	-2.41%	***
Car In-Vehicle Time down 10%[1]	+1.66%	+1.44%	+1.47%	**
Transit In-Vehicle Time down 10%[1]	-0.68%	-0.67%	-0.63%	*
Roadway Capacities down 10%	-0.57%	-0.46%	-0.49%	*
Gasoline Cost up 10%	-0.50%	-0.46%	-0.46%	*
Transit Wait Time down 10%	-0.48%	-0.35%	-0.40%	*
Parking Costs up 10%[3]	-0.45%	-0.26%	-0.34%	*
Parking Costs up $0.50[3]	-4.20%	-2.80%	-3.37%	***
Transit Walk Time down 10%	-0.42%	-0.23%	-0.32%	*
Transit Fare down 10%	-0.34%	-0.21%	-0.27%	*
Collector Road Speeds down 10%	-0.32%	-0.24%	-0.27%	*

[1] Reductions in travel times simulate the effect of moving activities physically closer together, and thus relate to changes in the density and land use mix.

[2] *** = strongest impact on auto VKT, ** = medium impact, * = minor impact

[3] A 10% increase in parking costs had little impact on auto use because there were no parking charges at many locations in Edmonton at the time of the survey. Increasing a zero cost by 10% results in a cost that is still zero. However a 50¢ increase substantially reduces auto use.

Conclusions

Of the different groups of variables examined (see "Methodology"), household demographic variables have the largest influence on auto use. Household auto ownership has the largest single influence. Other demographic variables, including household size and income, strongly influence the quantity of auto use. The strongest influences on automobile ownership are the number of people in the household, automobile accessibility for the home zone, and household income.

Mode-specific accessibilities (measures that represent the proximity of activities, such as jobs and housing, and the ease and costs of travel between them) also have strong influences on household auto use. Making activities physically closer and increasing parking costs result in substantial reductions in daily household VKT. For example, a 50¢ increase in parking costs can result in a 3.4% reduction in VKT. Also, by reducing walking times by 10% by making activities closer together, VKT can be reduced by 3.3%. As auto accessibility increases (i.e. easier and cheaper to travel by car) at both the home and work locations, households tend to own more automobiles and make much greater use of autos overall. As walk accessibility at the home location increases, households tend to own fewer autos and make less use of their autos overall.

The influences of accessibility measures on auto use are much greater than the influence of density on its own. Population and employment density variables can appear to have strong influences in regression equations concerning auto use when other variables, such as household income, which are correlated to density, are excluded. The apparent influence of density largely disappears when other correlated variables, in particular mode-specific accessibility, are included in the equations. This indicates that it is more appropriate to use mode-specific accessibility than densities, since they capture the complex interplay between a wide range of factors, including proximity of activities. While density is a factor in the proximity of activities, it should be considered in combination with land use mix and other accessibility factors.

Household travel patterns are highly variable. Much of the variation in auto use is not explained by the set of factors considered explicitly in this study. The R^2adj values for the various estimation runs did not exceed 0.33.

Road patterns have minor influences on auto use. Regular, rectangular street patterns tend to be associated with slightly less auto use than curvilinear street patterns. Access to transit also has a minor influence on auto use. As transit accessibility at the home location increases, households tend to own slightly fewer automobiles and make somewhat less use of autos overall. Consistent with this, households located in zones without transit services tend to own more cars and make more use of autos overall.

Policy Implications of Findings

While this study shows that automobile use is largely influenced by factors beyond the reach of planners and engineers, it also indicates that measures that improve walk, transit, and bike accessibility and that reduce auto-accessibility can result in substantial reductions in household automobile use. The influence is greatest when these measures are applied in combination. Such measures include:

- reducing walk time by locating activities closer together, which could be achieved through intensification, and mixed-use development;
- increasing parking charges;
- making walking and bicycling routings more direct;
- ensuring that street designs are more pedestrian-friendly, for example by providing attractive streetscaping, bus shelters, streets that are easy to cross, and pedestrian scaled spaces (e.g. small parking lots and buildings that are closer to streets);
- introducing measures to slow down autos, such as traffic calming on existing streets and designing narrower roads in new communities;
- encouraging regular rectilinear street patterns over curvilinear patterns;
- reducing bus fares; and
- introducing bus priority measures in order to reduce bus running times.

Project Manager: Susan Fisher

Project report: Impact of Urban Form And Travel Accessibility on Private Vehicle Use, 1999

Project Consultants: Hunt Analytics Inc.

A full report on this project is available from the Canadian Housing Information Centre at the address below.

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Canada Mortgage and Housing Corporation
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Ottawa, ON K1A 0P7

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